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A SYSTEM AND METHOD FOR IMPLEMENTING A SOFTWARE BRIDGE/ROUTER WITHIN A COMPUTER NETWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to and the benefit of the filing date of U.S. Provisional Application Serial No.60/135,726, filed on May 25, 1999, and entitled "Soft Bridge/Soft Router," which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

The present invention generally relates to computer networking and, more particularly, is related to a system and method for implementing a software bridge / router between a series of computers in a network.

BACKGROUND OF THE INVENTION

With the advancement of technology, computer prices have decreased substantially. Such decreases in computer prices have enabled individual home owners to have two or more computers within their place of residence or home office. Therefore, communications and computer vendors focus on providing various forms of network solutions that allow multiple computers to interconnect, share files, share peripherals such

as printers and scanners, and generally interoperate as a small network. Due to an increase in the number of PCs within a household, the concept of computer networking within a home, otherwise known as small office, home office (SOHO) networking has emerged as a new networking medium, outside of basic computer networking, which sets forth new complications and considerations to be addressed by equipment manufacturers and vendors.

One of the least complicated networking options for the SOHO environment is centered around hubs and network interface cards (NIC). As known by one skilled in the art, a hub is a common connection point for devices within a network which is used to connect segments of a local area network (LAN).

A user desiring to interconnect multiple computers within their home, typically purchases and installs a small hub, otherwise referred to as a bridge/router, such as, for example, a 10/100 base T hub, and installs special cables from each computer within the home office to the hub, thereby establishing a connection, between all computers. The user is then required to open their computers and install a NIC, such as, for example, a 10/100 base T NIC, inside of each computer. Finally, the user must configure/add software to their computers to begin operating in a local area network environment.

If the user desires to connect their SOHO network with a wide area network (WAN), additional complexity is required at the hub, or bridge/router, thereby raising

costs and complexity, neither of which are appropriate for the SOHO market segment where lower cost and minimal complexity are essential.

SUMMARY OF THE INVENTION

In light of the foregoing, the preferred embodiment of the present invention generally relates to a system for implementing a bridge/router in software that logically connects at least two local area networks, within a small office, home office (SOHO) network, to a wide area network.

Generally, within the SOHO network, each computer within a first and second local area network (LAN) stores a bridge/router software package prior to initiation of the LANs. At initiation, all computers within the first and second LANs obtain the media access control (MAC) address of all other computers within the SOHO network. The first computer to locate a digital subscriber line then becomes a master PC and all other computers become slave PCs.

Data to be transmitted from the first local area network to the second local area network, or visa-versa, is first transmitted to the master PC, which determines whether the data is to be transferred within the SOHO or to a wide area network (WAN). If the master PC determines that the destination of the data is one of the slave PCs, the master PC transfers the data to its intended destination slave PC according to the previously

obtained media access control addresses, thereby logically connecting the first and second LAN via the software bridge/router provided by the master PC.

When data is to be transmitted from a computer within the SOHO network to the WAN the data is transmitted to the master PC. If the master PC determines that the destination of the data is the WAN, the master PC performs a protocol conversion if necessary and then logically connects the SOHO to the WAN for data transmission. Similarly, when data is to be received by a computer within the SOHO network, from the WAN, the WAN transmits the data to the master PC, which then performs a protocol conversion if necessary and transmits the data to the appropriate slave PC.

The invention has numerous advantages, a few of which are delineated hereafter as examples. Note that the embodiments of the invention, which are described herein, possess one or more, but not necessarily all, of the advantages set out hereafter.

One advantage of the invention is that it provides a bridge/router between two separate networks without requiring additional complexity, cost, wiring changes, maintenance, or a single point of failure of a hub.

Another advantage is that the bridge/router is capable of being maintained even after a computer acting as the logical bridge/router between the first and second local area networks ceases to function.

Other features and advantages of the present invention will be or become apparent to one with skill in the art upon examination of the following drawings and detailed

description. It is intended that all such additional features and advantages be included herein within the scope of the present invention, as defined by the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more fully understood from the detailed description given below and from the accompanying drawings of the preferred embodiments of the invention, which, however should not be taken to limit the invention to the specific embodiments, but are for explanation and better understanding. Furthermore, the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present invention. Finally, like reference numerals in the figures designate corresponding parts throughout the several drawings.

FIG. 1 depicts a typical computer system having a PCI slot therein that may accommodate a LAN card, in accordance with the preferred embodiment of the invention.

FIG. 2 is a block diagram of a software bridge/router system comprising a SOHO network connected to a WAN prior to initiation of the software bridge/router software.

FIG. 3 is a flow chart that illustrates functions performed by the software bridge/router system to enable access within the SOHO network of FIG. 2, and from the SOHO network of FIG. 2 to the WAN of FIG. 2.

FIG. 4 is a block diagram of the SOHO network of FIG 2 connected to the WAN of FIG. 2 after initiation of the software bridge/router software of the preferred embodiment of the invention.

FIG. 5 is a flow chart that illustrates data transfer between computers within the SOHO network of FIG. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the preferred embodiment of the present invention, which is intended to be a non-limiting example, the system is implemented in software that is executed by a computer, for example, but not limited to, a personal computer, a workstation, minicomputer, or mainframe computer. The software based system, which comprises an ordered list of executable instructions for implementing logical functions, can be embodied in any computer readable medium for use by, or in connection with, an instruction execution system, apparatus, or device such as a computer based system, processor containing system, or other systems that can fetch the instructions from the instruction execution system, apparatus, or device and execute the instructions. In the context of this document, a "computer readable medium" can be any means that can contain, store, communicate, propagate or transport the program for use by or in connection with the instruction execution system, apparatus or device. The computer readable medium can be, for example, but not limited to, an electronic, magnetic, optical,

electromagnetic, infrared or semiconductor system, apparatus, device, or propagation medium. More specific examples (a non-exhaustive list) of the computer readable medium would include the following: an electrical connection (electronic) having one or more wires, a portable computer diskette (magnetic), a random access memory (RAM) (magnetic), a read only memory (ROM) (magnetic), an erasable program read only memory (EPROM or flash memory) (magnetic), an optical fiber (optical), and a portable compact disk read only memory (CDROM) (optical). Note that the computer readable medium could even be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via for instance, optical scanning of the paper or other medium, then compiled, interpreted or otherwise processed in a suitable manner, if necessary, and then stored in a computer memory.

Referring now to the drawings, wherein like reference numerals designate corresponding parts throughout the drawings, FIG. 1 illustrates a typical computer or processor based system 2, having a PCI slot 16 therein, that may be used to implement a software bridge/router in accordance with the preferred embodiment of the invention. FIG. 1 shows a computer system 2 generally comprising a processor 4, a storage device 5, and a computer memory 6 having an operating system 8. Software bridge/router software 100, which defines the functionality of the software bridge/router, is located within the memory 6 of the computer system 2. The processor 4 accepts data from the computer memory 6 or a local interface 10, such as a bus(es) or a dedicated path. Specifically, with

regard to the preferred embodiment of the invention, the local interface 10, located in the computer 2, is a PCI bus.

The computer system 2 also includes input device(s) 12 and output device(s) 14. Generally, this system may run any of a number of different platforms and operating systems, including, but not limited to, the UNIX®, Windows NT®, SunSolaris® or any such operating system. The PCI slot 16 is attached to the local interface 10 and provides a means for a peripheral device, such as a network interface card (NIC), to attach to the computer system 2.

FIG. 2 is a block diagram of a software bridge/router system 20 comprising a SOHO network 30 connected to a WAN 60, prior to initiation of the software bridge/router software 100 (FIG. 1). Preferably, the SOHO network 30 is connected to the WAN 60 via a digital subscriber line (DSL). As known in the art, connection of a SOHO network to a WAN provides computers within the SOHO network with features such as, but not limited to, Internet access. Connection between the SOHO network 30 and the WAN 60 is preferably provided via a first xDSL modem (not shown) located at the SOHO network 30 and a second xDSL modem (not shown) located at the WAN 60. The SOHO network 30 of FIG. 2 comprises a first LAN 40 and a second LAN 50, either, or both of which are connected to the digital subscriber line (DSL) and at least one plain old telephone service (POTS) line. As known in the art, the WAN 60 comprises a central office 62 that provides for numerous types of services. Such services may include, but

are not limited to, asymmetric digital subscriber line (ADSL) services, high bit rate digital subscriber line (HDSL) services, symmetric digital subscriber line (SDSL) services, multirate digital subscriber line (MSDSL) services, and/or rate adaptive digital subscriber line (RADSL) services.

It should be noted, that while the present disclosure describes use of two separate LANs within the SOHO network 30, one skilled in the art will appreciate that the number of LANs need not be limited to two, but may instead be more than two. In fact, the number of LANs within the SOHO network 30 may even be limited to a single LAN comprising a series of computers. Further, the number of plain old telephone service lines and DSL lines may also differ from the number illustrated as an example in FIG. 2.

As shown by FIG. 2, the first LAN 40 comprises a series of computers therein, illustrated as PC1 42, PC2 44, PC3 46, and PC4 48, and the second LAN 50 comprises a series of computers therein, illustrated as PC5 52, PC6 54, and PC7 56. To provide LANs, each computer within the first and second LANs 40, 50 contains a NIC that connects to the PCI slot 16 (FIG. 1) thereby providing networking capabilities within each respective network. Preferably, a LAN card is inserted into the PCI slot 16 (FIG. 1) of each computer to provide networking capabilities such that computers PC1 42, PC2 44, PC3 46, and PC4 48 are logically connected as the first LAN 40, and computers PC5 52, PC6 54, and PC7 56 are logically connected as the second LAN 50. As such, PC1 42,

PC2 44, PC3 46, and PC4 48 are physically connected in parallel, and computers PC5 52, PC6 54, and PC7 56 are physically connected in parallel.

Typically, as known in the art, if the first and second LANs 40, 50 are to be connected to allow communication amongst computers within the first LAN 40 and the second LAN 50 a small hub, such as, for example, a 10/100 base T hub, is installed, along with the installation of special cables from each computer within the home office to the hub. All computers must then have a NIC, such as, for example, a 10/100 base T NIC, installed. Finally, each computer within each LAN 40, 50 must have software added/configured to allow all computers to begin operation in a local area network environment. In addition since the SOHO network 30 is connected to a WAN 60, additional complexity is required at the hub, thereby raising costs and complexity, neither of which are appropriate for the SOHO market segment where lower cost and minimal complexity are essential. The present software bridge/router system, via implementation of the software bridge/router software 100, addresses these problems and provides an economical solution using xDSL technology.

FIG. 3 is a flow chart that illustrates functions performed by the software bridge/router system 20 to enable access within the SOHO network 30, and from the SOHO network 30 to the WAN 60 via implementation of a software bridge/router logically located between the first LAN 40 and the second LAN 50. As mentioned hereinabove, in order to extend communication between computers within the first LAN

40 and the second LAN 50, and between a single computer within the SOHO network 30 and the WAN 60, each computer within the SOHO network 30 comprises software bridge/router software 100 within its memory 6 (FIG. 1), the functions of which are performed by the processor 4 (FIG. 1) located therein. It should be noted that a number of topologies and architectures for LANs 40, 50 exist. Therefore, a system and method to interface the LANs 40, 50 to the WAN 60 in accordance with the preferred embodiment of the invention may be implemented with any number of different LAN configurations.

As shown by block 102 the SOHO network 30 is first initiated or powered up. When the SOHO network 30 is powered up the first and second LANs 40, 50 and all computers therein 42, 44, 46, 48, and 52, 54, 56 respectively, are powered up. As shown by block 104, when the first and second LANs 40, 50 are initiated, computers within each LAN determine whether they are connected to a digital subscriber line. In accordance with the preferred embodiment of the invention, the first computer to obtain access to the digital subscriber line becomes a master computer, or master PC as described in detail hereinbelow (block 106). As shown by block 108, after the master PC is determined, all other computers within the first and second LANs 40, 50 become slave PCs. FIG. 4 illustrates the SOHO network 30 after initiation of the software bridge/router software 100.

An example of a possible way in which the first computer becomes a master computer, and all other computers become slave computers is described in U.S. patent

number 6,011,781, entitled "Multipoint access protocol utilizing a point-to-point methodology," by Russell Bell, filed March 19, 1997, the disclosure of which is incorporated herein by reference.

As shown by block 110, the master PC then determines the media access control address of all computers within the first and second LANs 40, 50. The master PC then stores all media access control addresses within an address table that may be located within the data storage 5 of FIG. 1 (block 112). One skilled in the art will appreciate that the location of the address table need not be limited to within the data storage (FIG. 1), but may instead may be located external to the master PC. Therefore, by obtaining the media access control addresses, the master PC obtains information necessary to allow data communication between the first and second LANs 40, 50.

Therefore, addressing FIG. 4, the PC master determines the media access control address of slave PCs 1-6. It should be noted that, as mentioned hereinabove, all computers within the first and second LANs 40, 50 have the capability of being a master PC and determining all media access control addresses since the software bridge/router software 100 has been installed therein. Further, since the process of determining the media access control addresses of computers located in a separate LAN is known by those skilled in the art, discussion of the learning process, algorithms and techniques used to learn the media access control addresses is not provided herein. In accordance with an alternative embodiment of the invention, at initiation, all computers within the first and

second LANs may obtain the MAC address of all other computers within the SOHO network.

Preferably, a refresh cycle is performed by each computer within the first and second LANs 40, 50, as defined by the software bridge/router software 100, to ensure that the master PC has not ceased functioning. Therefore, should a master PC fail either as a result of hardware or software problems, the SOHO network 30 may be reconfigured to provide a new master PC. Specifically, if the master PC ceases to function, the first computer to detect the DSL then becomes the new master PC, while all other computers within the first and second LANs 40, 50 become slave PCs.

As defined by the software bridge/router software100, the master PC also provides a logical connection between the SOHO network 30 and the WAN 60. This logical connection allows computers within the SOHO network 30 to obtain Internet access, thereby providing for the transmission and reception of data between the WAN 60 and SOHO network 30 computers. As known in the art, bandwidth spectrum allocation provides LAN communication at high frequencies, while WAN traffic (DSL signals) exist at lower frequencies. This allows both LAN and WAN traffic to exist at the same time.

FIG. 5 is a flow chart illustrating data transfer between computers of the first and second LANs 40, 50, and between the SOHO network 30 and the WAN 60 which is made possible by the software bridge/router provided by the master PC. It should be noted

herein that while this example describes the transmission of data from a computer located within the first LAN 40 to a computer located within the second LAN 50, one skilled in the art will appreciate that the transmission of data from a computer located within the second LAN 50, to a computer located within the first LAN 40 works essentially the same.

In accordance with the preferred embodiment of the invention, when a first slave PC located within the first LAN 40, such as slave PC 1 of FIG. 4, seeks to transmit data, either to a second slave PC located within the second LAN 50, such as slave PC 6 of FIG. 4, or to the WAN 60, the first slave PC transmits the associated data to the master PC (block 202). Data is typically transmitted in data packets, each of which contains information regarding the destination of the data packets. As shown by block 204, the master PC then analyses the received data packets to determine the destination of the received data.

As shown by block 206, if the received data packets are intended to be transmitted to a second slave PC, the master PC then checks the address table, preferably located within data storage 5 (FIG. 1), to determine whether the media access control address of the destination slave PC has been previously stored by the master PC. As shown by block 208, if the destination media access control address is known by the master PC, the master PC transmits the data to the slave PC within the second LAN 50, in accordance with known bridging/routing techniques.

In accordance with an alternative embodiment of the invention, after determining the destination slave PC of received data (block 206, FIG 5), the master PC may transmit a PING signal to the destination slave PC to determine which data path to the destination slave PC has the least latency. If more than one line, or channel, may be used to transmit the data to the destination slave PC, the line or channel returning with the least latency is used for the transmission of data, thereby providing the most efficient network possible.

As shown by block 210, if the received data packets are intended to be transmitted to the WAN 60, the master PC determines the protocol requirements of the WAN 60. If the protocol requirements of the WAN 60 require a change in protocol, the master PC performs a protocol change by using a technique known to those skilled in the art. Once necessary protocol conversion has been performed the master PC transmits the received data packets to the destination WAN 60 (block 212).

It should be emphasized that the above-described embodiments of the present invention, particularly, any "preferred" embodiments, are merely possible examples of implementations, merely set forth for a clear understanding of the principles of the invention. Many variations and modifications may be made to the above-described embodiment(s) of the invention without departing substantially from the spirit and principles of the invention. All such modifications and variations are intended to be included herein within the scope of present invention and protected by the following claims.